Chapter 3
Soils and Geology

This chapter addresses the existing soils and geology and evaluates potential impacts associated with the proposed project of gravel extraction and processing operations. The methodology and analysis are discussed in more detail in Appendix B.

3.1 Existing Conditions

3.1.1 Topography

Grouse Ridge is roughly L-shaped and rises to elevations ranging from approximately 1,320 to 1,650 feet above mean sea level (msl) (Figure 2-1). The Upper Site lies on the flat ridge atop the southeast limb of the ridge, with steep slopes to the north and south. Grouse Ridge is between the Middle and South Forks of the Snoqualmie River. Seven Bonneville Power Administration (BPA) utility towers are located along the southern boundary of the Upper Site (Figure 3-1).

The Lower Site lies at the northwest base of Grouse Ridge at an approximate elevation of 690 feet above msl, on a natural flat terrace that extends west to the town of North Bend (Figure 2-1). Interstate 90 (I-90) is located to the south and separates the Lower Site from the South Fork of the Snoqualmie River. Across the terrace to the north, the Middle Fork of the Snoqualmie River winds around and past Grouse Ridge.

3.1.2 Regional Geologic Setting

The project site and the Puget Lowlands have been subject to several continental glaciation events during the past 1 million years. Repeated advances and retreats of glaciers in British Columbia resulted in the formation of a mountain ice sheet. Continued growth of the ice sheet in British Columbia resulted in the southward advance of an ice lobe into the Puget Lowland (the Vashon Stade) about 19,000 years ago. In addition, glaciers in the Cascades extended west and merged with the main lobe.

Upon withdrawal of the Puget glacier, both the Middle Fork and South Fork of the Snoqualmie River eroded away much of the material that was transported and deposited by the glacier, leaving isolated plateaus such as Grouse Ridge. The recession of the glacier also left a broad swath of coarse soils (now referred to as glacial outwash soils) beneath the Sallal Prairie to the west and below Grouse Ridge.

Some of the eroded materials were incorporated into the Vashon till, a non-sorted, non-layered sediment deposited directly by the glacial ice. Most of the Vashon till is very compact because it was “plastered” onto the ground surface under the weight of several thousand feet of ice.

The Lower and Upper Sites are primarily located over these glacial outwash deposits. These deposits range from moderately sorted gravel along rivers to poorly sorted gravelly sands deposited from small tributaries. The Upper Site lies over outwash soil deposits. These deposits consist of layered sand and gravel (aggregate), moderately to well sorted, and well bedded silty sand to silty clay.

3.1.3 Site Geology

3.1.3.1 Lower Site

Within the Lower Site boundaries, seven exploratory boreholes were drilled by Cadman, Inc. and URS to investigate the quality and extent of the glacial deposits, as well as groundwater conditions. The borings were completed from 80 to 270 feet below ground surface (bgs). Four of the borings were completed as monitoring wells.

In addition to drilling, bulk sampling was completed by Cadman, Inc. to determine the contents of the deposit. Approximately 6,000 cubic yards was excavated over a period of 2 days. The excavations extended to depths of up to 40 feet below grade.

Soils within the Lower Site can be generally described as grayish brown and gray, slightly silty sands and gravels. Cadman, Inc. has determined that economically marketable sand and gravel exist to depths of up to 130 bgs, with the exception of sporadic silt zones. The proposed depth of excavation of the Lower Site is approximately 70 feet (Elevation 620 feet above msl). Silt zones become more predominant at elevations below the planned mining depth.

3.1.3.2 Upper Site

Twenty-one exploratory boreholes were drilled on the Upper Site by Cadman, Inc. and URS. Eleven of these boreholes were completed as monitoring wells. Soils encountered in the borings are generally brown to gray silty sands and sandy gravels. Cadman, Inc.’s initial estimates show marketable sand and gravel extending to 270 feet bgs, with the exception of occasional sandy silt and silt zones. These zones are found at various depths throughout the Upper Site and appear more extensive near the northwest and southeast margins of the proposed excavation area. These finer-grained soils range from 10 to 70 feet in thickness.

The ridge on the Upper Site ranges in elevation from 1,600 feet above msl on the southeast to approximately 1,650 feet above msl to the northwest. The proposed excavation at the Upper Site would extend down 65 to 115 bgs (1,535 feet above msl). This excavation depth would pass through the sandy silt and silt zones, predominantly at the northwest portion of the Upper Site.

3.1.3.3 Conveyor Belt Alignment (Lower Site to Upper Site)

Two exploratory boreholes were drilled by Cadman, Inc. close to the proposed conveyor route. Investigations revealed deposits of sands and gravels at least 45 feet thick on the lower half of the route, underlain by clay. The sand and gravel deposits increase in thickness with an increase in elevation. Sand and gravel deposits farther up the ridge are at least 50 feet thick.

3.1.4 Geologically Hazardous Areas

Geologically hazardous areas are lands susceptible to landslides, erosion, or seismic movement due to the underlying soils and geology. The areas surrounding the proposed project limits are considered geologically hazardous areas because of the steep slopes where erosion and landslides have occurred in the past.

Steep slopes bound the Upper Site to the north and south. Steep slopes are defined in King County's Sensitive Areas Ordinance as any slope greater than 40 percent, which represents a geological hazard with respect to landslides. Most landslide hazard areas in the Grouse Ridge vicinity involve relatively loose soil on slopes underlain by denser and typically less permeable till. The locations of these geologically hazardous areas are shown in the North Bend Gravel Operation Exit 38/Homestead Valley Alternative Technical Assessment (Hart Crowser, 1999b).

3.1.5 Seismic Hazards

North Bend is in an active seismic region of the Pacific Northwest, where the primary tectonic feature is the Cascadia Subduction Zone. In this zone, the Juan de Fuca oceanic plate is being pushed (subducted) under the North American continental plate. This zone is responsible for the larger recent earthquakes, including the 1949 Olympia (Magnitude 7.1), the 1965 Seattle (Magnitude 6.5), and the 2001 Nisqually (Magnitude 6.8) earthquakes. Recent evidence suggests that larger earthquakes have occurred in historic times, including an event approximately 300 years ago that may have been as large as Magnitude 8.5.

The project area is in Seismic Zone 3 in the 1997 Uniform Building Code (UBC), as is all of western Washington. Per the UBC zonation, Zone 1 indicates the region of lowest seismic risk and Zone 4 indicates the region of highest seismic risk. Therefore, the project area is in a region of relatively high seismic risk.

National maps of earthquake shaking hazards provide information essential to creating and updating the seismic design provisions of building codes used in the United States. Scientists frequently revise these maps to reflect new knowledge. Buildings, bridges, highways, and utilities built to meet modern seismic design provisions are better able to withstand earthquakes, not only saving lives but also enabling critical activities to continue with less disruption. Structures built in accordance with UBC and current engineering standards are designed to perform well with minimal damage from ground shaking.

Available studies of seismic hazards have designated soils within the proposed project boundaries as having a low susceptibility to liquefaction. Liquefaction takes place when loosely packed, waterlogged sediments at or near the ground surface lose their strength in response to strong ground shaking. Land use planning strategies and engineering measures can be used to reduce the health and safety risk due to seismic hazards in hillside areas where landslides and rock fall are possible.

3.2 Environmental Impacts

3.2.1 Construction Impacts

3.2.1.1 Alternative 1–No Action

Timber harvesting that would occur under the No Action Alternative could result in impacts such as soil erosion. Without specific proposals, it is not possible to quantify potential impacts.

3.2.1.2 Alternative 2–Proposal: Lower and Upper Sites Mining (Including Limited Lower Site Mining)

There are a number of earth activities in Alternatives 2 and 2A that are considered construction impacts to the soils and geology in the study area. The indirect impacts in Alternatives 2 and 2A include:

- Construction and improvement of roadways
- Construction of a conveyor system with a maintenance road
- Construction of earthen berms
- Reclamation activities
- Clearing and preservation of topsoil and woody debris

Construction and Improvement of Roadways

During the first phases of mining, the Lower Site would be extracted over about 5 years. During this time, access roads to and within the pit would have to be improved and constructed. A road to Exit 34 already exists, and was primarily constructed during previous mining of the area.

The roadway would have to be improved, but would have little impact on the soils due to the flat topography of the alignment.

Construction of a Conveyor System With a Maintenance Road

The final conveyor and maintenance road route from the lower pit area up the west slope of Grouse Ridge would be laid out, in a straight line up to the Upper Site. This alignment stretches approximately 5,300 feet and rises 800 feet in elevation. The conveyor would use a 36- or 42-inch-wide belt and average about 4 to 5 feet above the grade. It would include a cover to blend in with vegetation, and to prevent rainwater and debris from mixing with the aggregates. Tree branches would be permitted to grow over the conveyor.

The conveyor corridor width is proposed to be 20 feet, wide enough to accommodate the conveyor, maintenance road and a water-pipe system. This width is exclusive of grading the slopes on either side.

The maintenance road width alone is estimated at 15 feet, exclusive of any grading. This road would parallel the conveyor along most of its length, and depart from the conveyor alignment in three areas, as illustrated in Figure 3-2. These road segments are based on local topographic features such as knobs and avoid the steepest portions of the alignment. The maintenance road would not be paved and would have minimal vehicle traffic, similar to an access road for a ski lift.

Conventional conveyor haulage systems have an optimum-working grade of 16 to 17 degrees (28 to 30 percent grade). Calculations indicate that, in general, the route is equal or less than this limit and, as such, would require regrading of the natural ground line. This regrading comprises cut and fill slopes, with proposed slope gradients of 1.5 horizontal to 1 vertical (34 degrees). This result would create a corridor ranging from 70 feet to 110 feet wide, with the wider clearing required along the upper 800 feet of the conveyor as it traverses the ridge to the Upper Site.

Both the conveyor system and maintenance road could increase the likelihood of offsite impacts such as landslides, increased streambank erosion, and increased sediment delivery. This is primarily due to the fact that improperly designed roads and slopes, could concentrate runoff flows or change natural drainage patterns. Cut slope gradients of 1.5 horizontal to 1 vertical (34 degrees) would be subject to site specific design based on a complete geotechnical analysis. The USGS map of the Snoqualmie Pass (1986), indicates that this area consists of recessional outwash deposits. If these soils become saturated or contain any perched water layers, flatter slopes and/or subsurface drainage may be required to ensure slope stability.

Due to public concerns raised in comments on the DEIS, the alignment was re-evaluated with a site visit made on February 2, 2000, by a URS engineer and engineering geologist. It was found that the trees along the alignment, aged between 10 to 30 years, showed no curvature or leaning that could be indicative of recent landslide movement. No landslide scars were apparent and logging roads up the ridge were cut into sandy gravels. These soils are consistent with the local geology for area and two subsurface exploration boreholes drilled by Cadman, Inc. close to the alignment in 1998.

No adverse seismic risks were identified that cannot be addressed at the detailed design stage.

Construction of Earthen Berms

After an estimated 5 years of extraction, operations at the Lower Site would cease and an operations/processing center would be built on the excavated floor. Roads, building floors, and maintenance areas would be paved. Earthen berms would be constructed in the early phase around the mine boundary to restrict views and control noise. One earthen berm would be located to the north and one to the south. This activity would have little impact on the soils.

Reclamation Activities

The Surface Mine Reclamation Act is a reclamation law that requires a permit for each mine that: (1) results in more than 3 acres of disturbed ground, or (2) has a high-wall that is both higher than 30 feet and steeper than 45 degrees (Chapter 78.44 Revised Code of Washington [RCW], Chapter 332-18 Washington Administrative Code [WAC]).

The original Mine Reclamation Act passed in 1971 was amended in 1993 to assure that every mine in the state is thoroughly reclaimed. The Washington State Department of Natural Resources (WDNR) is responsible for ensuring that reclamation follows completion of surface and underground mining. WDNR has exclusive authority to regulate mine reclamation and approve reclamation plans.

Mine operations, which are all mine-related activities except reclamation, are specifically to be regulated by local governments or state and federal agencies exclusive of WDNR.

Local governments must formally approve mine siting and/or the subsequent use of the mine site (RCW 78.44.091) prior to receiving a reclamation permit. This approval process generally makes local jurisdictions the lead agency according to State Environmental Policy Act (SEPA) rules.

A high-quality reclamation plan is required for each mine, and periodic review and modifications are necessary. These plans specify the permit holder's methods for achieving the following reclamation goals:

- Segmental or progressive reclamation
- Preservation of the topsoil
- Slope restoration such that highwalls are rounded in plan and section for all mines

- Stable slopes
- Final topography that generally comprises sinuous contours, chutes and buttresses, spurs, and rolling mounds and hills, all of which blend with adjacent topography to a reasonable extent
- Effective revegetation with multi-species ground cover and trees

Pursuant to a WDNR-approved reclamation plan, the mine sites would be progressively reclaimed over an approximately 25-year mine life, including revegetation with trees. Reclamation sideslopes would be established during excavation of the sand and gravel deposit. No side-slope back filling is required to achieve reclamation standards. Reclamation of finished sand and gravel mine boundaries would include construction of slopes at a maximum 2 Horizontal (H):1 Vertical (V) (27 degrees) that would slope back into the mine. A 2H: 1V slope angle is substantially flatter than the natural angle of repose for in-place sand and gravel (e.g., 1.5H:1V, or 33 degrees), and more stable.

Reclamation of finished conveyor corridor is proposed to involve removing the conveyor, equipment and support structures. After which, the route would be graded, fertilized and planted to minimize erosion.

After vegetation growth, the long-term impacts to the soils and geology are expected to be low.

Clearing and Preservation of Topsoil and Woody Debris

Because soil is essential to successful reclamation, it would not be sold as a by-product of mining. Soil to be used during mine reclamation would be separately stockpiled. The stockpiles would be placed in adjacent areas that would not require disturbance for the life of any particular mining subphase. Stockpiles would be positioned to assist in shielding the excavation from view and to help mitigate noise impacts, but would not become permanent features such that they could be removed and used for sub-phase reclamation.

Soil stockpiles would be shaped and seeded with perennial grass seed mixtures suggested by the Natural Resources Conservation Service (NRCS), the Department of Natural Resources, and the Washington Department of Game, to reduce loss of fines into stormwater until such time as vegetation was reestablished. Shallow stormwater retention ditches would be excavated around soil stockpile perimeters, as needed, then drained to a retention pond. While retention of significant volumes of stormwater is not anticipated due to the porous, permeable nature of site soils, retained water would be pumped back into a settling pond located within the plant site and then directed into the wash water recirculation system.

Impacts associated with Alternative 2A would be less than Alternative 2 because of the smaller area of impact (6.5 acres less).

3.2.1.3 Alternative 3–Lower and Upper Sites Mining (Including Limited Lower Site Mining)

Construction impacts associated with Alternatives 3 and 3A would be less than Alternatives 2 and 2A because of the absence of the conveyor belt and maintenance road on the western edge of Grouse Ridge. In essence, landslide and erosion issues posed by the conveyor and maintenance road route would be avoided. However, as discussed in Chapter 14, Transportation, SE Grouse Ridge Road is too narrow for truck traffic, and it is recommended that the roadway be widened to King County standards to permit truck traffic in both directions. This could require that up to 2,200 feet of additional roadway be built around the Washington State Patrol Fire Training Academy to access the Upper Site. This roadway upgrade would involve fill and blasting in several locations and would have a high impact on the soils and geology.

3.2.1.4 Alternative 4–Upper Site Mining - Exit 38

Impacts associated with Alternative 4 would be similar to, but less than, Alternative 3. Roadway upgrades to SE Grouse Ridge Road would be the same and, as such, would have a high impact on the existing soils and geology.

3.2.2 Operation Impacts

3.2.2.1 Alternative 1–No Action

No soils and geology impacts would be associated with the No Action Alternative.

3.2.2.2 Alternative 2–Proposal: Lower and Upper Sites Mining (Including Limited Lower Site Mining)

Phased site development would require sequential removal of vegetation and soil stripping from areas to be mined. This activity would increase susceptibility to erosion, of both unvegetated stockpiled soil and denuded or excavated ground, until soil replacement and plant stabilization are accomplished. Gravel would be removed from the Upper Site over a long period of time, approximately 25 years. Excavation would be in small segments, 50 acres or less at a time. As excavation is completed, each segment would be regraded and planted with native vegetation. Because surface soil on both proposed sites is composed of a coarse gravelly and sandy nature, soil stripping would be a relatively simple and clean process. Some of the fines within the soil would be lost to stormwater flow. However, due to the absence of significant surface water streams associated with the sites and the porous granular nature of site soils, sediment-laden surface water would not be expected to be generated in significant volumes or to have significant onsite travel distance and, hence, would create only low level erosional impacts.

The removal of soil from the Upper Mine at the crest of Grouse Ridge would reduce the weight of soil that could potentially destabilize the slopes between I-90 and the ridge and therefore improve the global stability. Since the glacial soils are highly erodible, surface water runoff and groundwater seeps will be carefully controlled and discharged to prevent erosion. Collection and infiltration of the stormwater and perched groundwater within the Upper Site could impact the stability of the existing highwall mine at Homestead Mining, located along part of the southern boundary. The Upper Mine stormwater and groundwater infiltration system would be designed to reduce groundwater flows toward the Homestead Mine which has a documented history of instability (Hart-Crowser, 1999a).

Six BPA utility towers are located along the southern boundary of the Upper Site with one of the towers within the footprint of the proposed excavation. BPA requires a horizontal buffer around the towers of 50 feet, measured from the point of contact between the leg and ground surface. Any slope after the buffer is required to have a 2H:1V slope. It is proposed that mining would extend as a 2H:1V slope from the 50-foot setback and that reclaimed slopes will have a slope of 3H:1V to 4H:1V. According to BPA representatives, no tower would be allowed to be isolated without provision for the construction of an access road. If this horizontal buffer and access road are maintained, there will be no impact.

3.2.2.3 Alternative 3–Lower and Upper Sites Mining (Including Limited Lower Site Mining)

Operation impacts associated with Alternatives 3 and 3A would be similar to, but less than, Alternatives 2 and 2A because of the absence of the conveyor line.

3.2.2.4 Alternative 4–Upper Site Mining - Exit 38

Impacts associated with Alternative 4 would be similar to, but less than, Alternative 3 because of a smaller excavation area (40 acres or less).

3.2.3 Cumulative Impacts

Alternatives 2, 2A, 3, 3A, and 4 would contribute to an overall depletion in the regional sand and gravel resources.

3.3 Mitigation Measures

3.3.1 Alternative 1–No Action

No mitigation measures are proposed under Alternative 1.

3.3.2 Alternatives 2, 3, and 4 (Including Limited Lower Site Mining)

Impacts of the Action Alternatives would be mitigated by complying with applicable regulations and applying standard design and construction practices common to the industry. In addition, the following specific mitigation measures are proposed:

- Following reclamation, the final slopes should be 3H:1V to 4H:1V to enable the use of standard forest management practices following reclamation.
- Extent of clearing and grading should be limited to minimize exposed soils from erosion.
- Cut and fill slopes along the conveyor and maintenance route should be designed to ensure slope stability (Alternatives 2, 2A, 3, and 3A only). Design details could include flatter slopes, brow ditches and sub-drains.
- Construction best management practices (BMPs) should include the use of silt fencing, barrier berms, plastic covering for exposed ground, sediment traps (hay bales), temporary sediment detention basins, and restricting construction activities to dry-weather periods to contain sediment on site. Straw mulch and erosion control matting should be used to stabilize graded areas and reduce erosion and runoff impacts on slopes.
- Final mine design, including grading plan and design of the conveyor alignment, should be reviewed and approved by King County.
- Access roads to the BPA towers on the Upper Site should be constructed and maintained to meet BPA's requirements. In addition, a slope inspection monitoring plan should be developed to ensure tower stability during mining operations.
- Surface water runoff should be controlled by collection in drainage ditches, and culverts and placement of erosion protection including riprap, jute matting (and other erosion protection products), and energy dissipating structures (if necessary).
- The Upper Site stormwater and groundwater infiltration system should be designed to reduce groundwater flows toward the Homestead Mine to reduce landslide hazards.
- Fines from the wash water and fines settling basin, as well as decomposed wood waste from vegetation clearing, should be combined with stockpiled topsoil to manufacture subsoil. This subsoil should be distributed as soon as possible after restoration of topography within each mining subphase. This should be followed by the placement of the stockpiled organic-rich topsoil on the cut slopes to serve as a stable rooting medium for trees. The topsoil should be a sufficient thickness to ensure the establishment of a forest.

3.4 Significant Unavoidable Adverse Impacts

Under the Action Alternatives, the natural topography would be altered, essentially leaving two bowl-shaped areas where the mines were.

Recent studies (WDNR, 2000) in the Snoqualmie Pass Quadrangle show that undiscovered sand and gravel reserves that can be effectively mined and processed are estimated on the order of 50 million tons. Currently, in some of the larger gravel pits in the Snoqualmie Pass quadrangle, discovered reserves are estimated at 146 million tons remaining, including 60 million tons for the Grouse Ridge site. Therefore, the total available reserves that can be mined in the Snoqualmie Pass quadrangle is estimated at 196 million tons. The proposed project would deplete the overall feasible reserves in the area by up to 60 million tons (31 percent).

As a result of the mining proposed, slope stability and erosion effects would occur along the conveyor alignment and along SE Grouse Ridge Road under Alternatives 3, 3A and 4. These effects could be significantly reduced through proper mitigation design, but not be altogether eliminated. Although there are no indications to suggest that there will be a significant impact to the drainage basin as a result of the proposed project, monitoring of drainage issues combined with corrective actions, if needed, should prevent any unidentified adverse impacts from occurring.